

REMARKS

Claims 1-25 were pending in this application. Claims 1-19, 21, 24 and 25 are cancelled and claims 20, 22 and 23 are amended by the present Amendment. No new subject matter has been added by these amendments. Therefore, claims 20, 22 and 23 remain in this application.

Specification Objections

The specification stands objected to for minor informalities. Specifically, the Examiner has provided a list of several typographical and grammatical errors found in the specification. The Applicant believes that the above amendments to the specification overcome the Examiner's informality objections. Reconsideration and withdrawal of these objections are respectfully requested.

Drawing Objections

The drawings stand objected to as failing to comply with 37 C.F.R. §1.84(p)(5) because reference character 610 in Figure 7 is not mentioned in the specification. The Applicant believes that the above amendments to the specification overcome the Examiner's objection. Reconsideration and withdrawal of this objection are respectfully requested.

35 U.S.C. § 112 Rejections

Claims 17-19 and 23-25 stand rejected under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which the Applicant regards as the invention. Specifically, the Examiner rejected claims 18 and 23-25 because it is not possible to tell the difference between a hole in the thin dielectric layer referred to as a "damaged spot" as opposed to a "pore". The Examiner further rejected claims 17 and 19 because the phrase "large lithographic margin" is a relative term, rendering the claims indefinite.

Claims 17-19, 24 and 25 have been cancelled by this Amendment, thus rendering the rejection of these claims moot.

The Applicant believes that the above amendments to claim 23 overcome the Examiner's indefiniteness rejections.

Reconsideration and withdrawal of this rejection are respectfully requested.

35 U.S.C. § 102 Rejections

Claims 16 and 18 stand rejected under 35 U.S.C. § 102(b) as being anticipated by United States Patent No. 5,751,012 to Wolstenholme et al. Claims 16 and 18 have also been rejected under 35 U.S.C. § 102(b) as being anticipated by each of the following references: United States Patent No. 6,236,059 to Wolstenholme et al., United States Patent Application Publication No. 2002/0197566 to Maimon et al. and United States Patent No. 5,536,947 to Klersy et al. (hereinafter "the Klersy patent").

Claims 16 and 18 have been cancelled by this Amendment, thus rendering the rejection of these claims moot.

Claims 20-25 have been rejected under 35 U.S.C. § 102(b) as being anticipated by United States Patent Application Publication No. 2002/0006735 to Zahorik et al. (hereinafter "the Zahorik application"). The Examiner has also rejected claims 20, 21, 23 and 24 under 35 U.S.C. §102(e) as being anticipated or fully taught by United States Patent Application Publication No. 2003/0209746 to Horii (hereinafter "the Horii application"). In view of the above amendments and the following remarks, the Applicant respectfully requests reconsideration of these rejections.

As defined by amended independent claim 20, the present invention is directed to a phase-change memory device including a lower dielectric layer; a lower phase-change resistor, at least a part of the lateral surface of the lower phase-change resistor being surrounded by the lower dielectric layer; a dielectric layer covering at least a part of the top surface of the lower phase-change resistor and including a pore having a smaller area than the top surface of the lower phase-change resistor; and an upper phase-change resistor filling the pore, extending to cover at least a part of the top surface of the dielectric layer and contacting with the lower phase-change resistor through the pore.

As defined by amended independent claim 23, the present invention is a phase-change memory device comprising: a lower phase-change resistor, at least a part of the lateral surface of the lower phase-change resistor being surrounded by a lower dielectric

layer; a dielectric layer covering at least a part of the top surface of the lower phase-change resistor and including a pore aligned to the top surface of the lower phase-change resistor, the pore having smaller area than the top surface of the lower phase-change resistor; and an upper phase-change resistor filling the pore, extending to cover at least a part of the top surface of the dielectric layer and contacting with the lower phase-change resistor through the pore.

Support for the amendments to claims 20 and 23 can be found in Figs. 16 and 17 and on page 22, line 29 of the specification.

The Zahorik application is directed to a memory cell including a non-volatile resistive memory element with a small active area. The Examiner contends that memory element 18 in Fig. 4 corresponds to phase-change memory device of the claimed invention. The Examiner further contends that memory element 18 includes a lower dielectric layer (i.e., dielectric barrier 52), a lower phase-change resistor (i.e., chalcogenide element 28) with part of its lateral surface surrounded by the lower dielectric layer (see Fig. 4) and a thin dielectric layer (i.e., insulating material 36) including a pore. The Zahorik application does not teach or suggest "an upper phase-change resistor filling the pore, extending to cover at least a part of the top surface of the dielectric layer and contacting with the lower phase-change resistor through the pore" as required by amended independent claims 20 and 23.

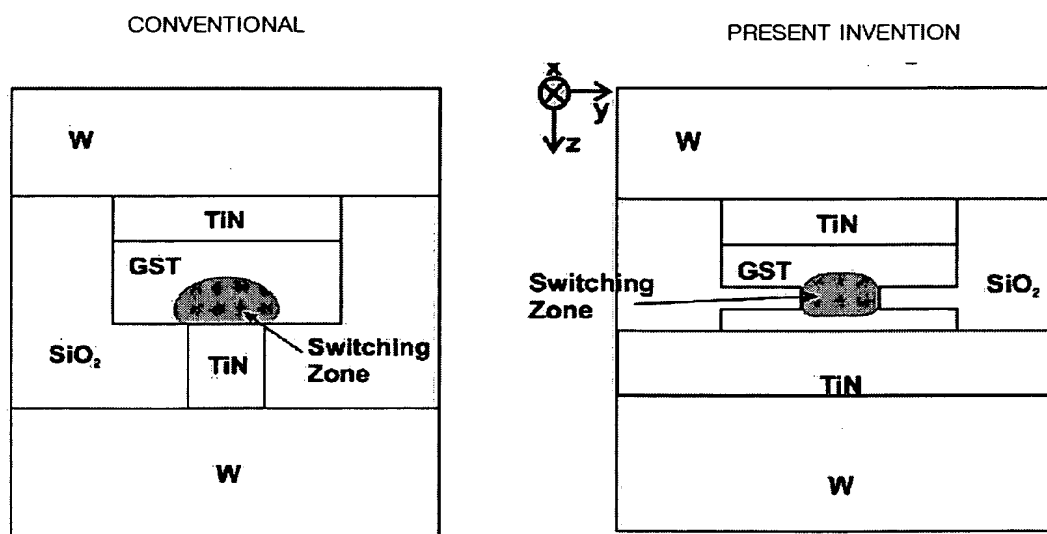
The Examiner contends that the space marked by 34 in Fig. 4 of the Zahorik application is equivalent to the upper phase-change resistor of the claimed invention. However, the space marked by 34 in the Zahorik application is a pyramidally-shaped or conically-shaped protruding contact portion extending from a chalcogenide element 28 (see paragraph [0034]). This contact portion 34 is not equivalent to the upper phase-change resistor of the claimed invention. Furthermore, contact portion 34 does not extend to cover at least a part of the top surface of the dielectric layer.

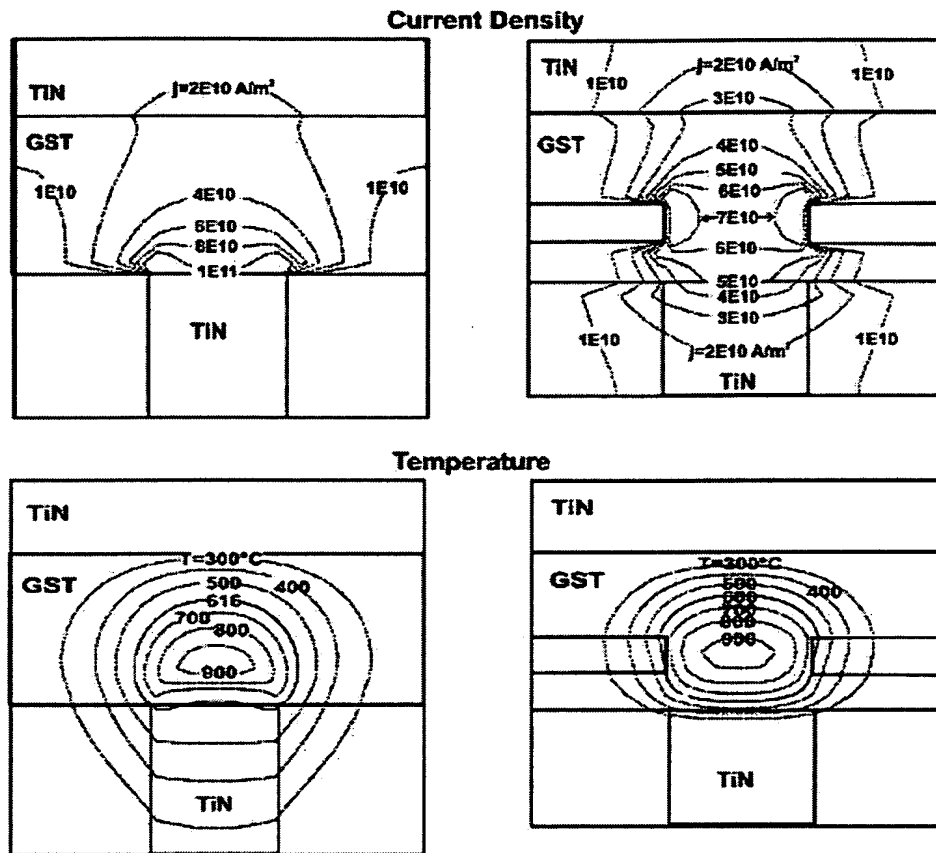
The claimed invention has several advantages over prior art phase-change memory devices. First, phase-change memory devices typically have a high current density around the pore. Local heating by the high current density can reduce the required level of current during operation of the phase-change memory device and thereby reduce operating power. Furthermore, in phase-change memory devices with a conventional structure, such as the one disclosed in the Zahorik application, the local heating around the pore can cause a

thermal stress, especially at the interface between the phase-change resistor and the electrode material. This thermal stress at the interface can make the memory device unreliable and reduce its lifetime. The phase-change memory device of the claimed invention provides an interface between the electrode and the phase-change resistor that is not adjacent to the pore since the pore is formed between the upper phase-change resistor and the lower phase-change resistor. Therefore, the thermal stress on the interface can be reduced.

Another advantage to the structure of the claimed invention arises from the fact that the melting of phase-change material is inevitable and causes volume expansion for phase transition between amorphous and crystalline. This also acts as a source of stress on the structure of the phase-change memory device. The claimed invention allows for a molten area that is away from the interface between the phase-change material and the electrode. Therefore, delamination of phase change material from the electrode due to both thermal and phase transition stress can be avoided and, thus, the reliability of the device is improved. Finally, compared to a conventional structure as disclosed in the Zahorik application, a molten region is away from the metal electrode, which is a good thermal conductor. Thus, less electric current is required to reach the melting temperature due to less heat loss through a metal electrode.

The following figures illustrate the differences, as discussed hereinabove, between the phase-change memory device of the claimed invention and conventional phase-change memory devices as discussed in the Zahorik application.





The Horii application is directed to an integrated circuit memory device including a semiconductor substrate and a first electrically insulating layer that extends on the semiconductor substrate and has a first contact hole therethrough. The Examiner contends that Fig. 2A illustrates a phase-change memory device including a lower dielectric layer (i.e., lower interlayer insulation layer 66 and upper interlayer insulation layer 75), a lower phase-change resistor (i.e., first barrier layer pattern 69 and phase-change material layer pattern 71) with part of its lateral surface surrounded by the lower dielectric layer (see Fig. 2A), a thin dielectric layer (i.e., insulating spacers 79) including a pore. The Horii application also fails to teach or suggest “an upper phase-change resistor filling the pore, extending to cover at least a part of the top surface of the dielectric layer and contacting with the lower phase-change resistor through the pore” as required by amended independent claims 20 and 23.

While the Horii application includes a plate electrode 83 that extends through the pore, this plate electrode is not equivalent to the upper phase-change resistor of the claimed invention.

For the foregoing reasons, the Applicant believes that the subject matter of amended independent claims 20 and 23 is not taught in or suggested by the Zahorik application or the Horii application. Reconsideration of the rejection of claims 20 and 23 is respectfully requested.

Claim 22 depends from and adds further limitations to amended independent claim 20 and is patentable for the reasons discussed hereinabove in connection with amended independent claim 20. Reconsideration of the rejection of claim 20 is respectfully requested.

35 U.S.C. § 103 Rejections

Claims 17 and 19 stand rejected under 35 U.S.C. § 103(a) for obviousness over the Klersy patent in view of United States Patent No. 6,495,470 to Sadjadi et al.

Claims 17 and 19 have been cancelled by this Amendment, thus rendering the rejection of these claims moot.

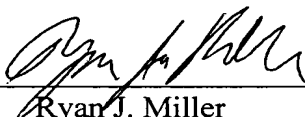
CONCLUSION

Based on the foregoing amendments and remarks, reconsideration of the rejections and allowance of pending claims 20, 22 and 23 are respectfully requested.

Respectfully submitted,

THE WEBB LAW FIRM

By



Ryan J. Miller
Registration No. 56,236
Agent for Applicant
700 Koppers Building
436 Seventh Avenue
Pittsburgh, Pennsylvania 15219-1845
Telephone: 412-471-8815
Facsimile: 412-471-4094
E-mail: webblaw@webblaw.com